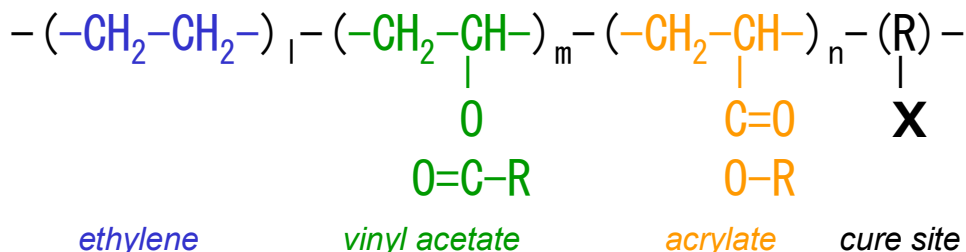


DENKA ER

Elastomer Copolymerized from Ethylene Vinyl Acetate and Acrylic Esters

Characteristics of DENKA ER

DENKA ER, developed originally by Denki Kagaku Kogyo K. K. is an elastomer copolymerized from ethylene, vinyl acetate and acrylic esters. It is a quiet special elastomer having excellent heat resistance and oil resistance.



In present application, rubber parts are used to the newest automobile, in severe conditions and complex deteriorating factors cause lower durability than expected. DENKA ER has an extremely excellent resistance to cyclic deterioration against to heat/ozone or heat/oil aging combined. DENKA ER has the performance that has such a requirement it meets. DENKA ER is suitable for the rubber parts required the highest cost and performance.

Table.1 shows typical 9 kinds of the synthetic rubber, rated approximately in weathering resistance, heat resistance, lubricant oil resistance, complex aging resistance and low temperature resistance.

Performance in comparison with Synthetic Rubbers

Rubber	Weather Resistance	Heat Resistance	Lubricant Oil Resistance		Cyclic Aging Resistance Oil & Heat	Low Temperature Resistance
			JIS No.1 Test Oil	Engine Oil		
DENKA ER	V	V	V	V	V	G
ACM	V	V	V	V	P	G
AEM	V	V	V	V	P	G
High Nitril NBR	P	F	V	F	—	G
ECO	V	G	V	P	—	V
Q	V	E	V	F	—	E
FKM	V	E	V	V	—	F
CSM	G	G	V	F	—	G
CR	F	F	V	F	—	G

* E; Excellent > V; Very good > G; Good > F; Fair > P; Poor, —; Out of Comparison

* JIS No.1 Test Oil : similar to ASTM No.1 Oil

* Engine Oil : Mobil 1 / SAE 5W-40, API Service SJ/CD

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Raw property of DENKA ER

DENKA ER has the six kinds in its grade, which the viscosity of each grade is adjusted to the range of 35 - 50 in consideration of processing in the rubber parts manufacture.

Fore kinds has the epoxy base cure site, that its cure speed isn't so fast, and two kinds has the carboxyl base cure site that this is so fast as curing site.

The raw form is in bale and the color is light yellow. DENKA ER is packed with 25Kgs craft paper bag.

Raw Property of DENKA ER

Type	Cure Site	Mooney Viscosity	Volatile Matter %
ER-3400	Epoxy	36 - 44	1% \geq
ER-5300	Epoxy	44 - 52	1% \geq
ER-8401	Epoxy	36 - 41	1% \geq
ANX-3	Epoxy	41 - 49	1% \geq
ER A403	Carboxyl	41 - 49	1% \geq
ER A804	Carboxyl	36 - 44	1% \geq

* Mooney Viscosity : ML₁₊₄ at 100°C

Heat & Oil Resistance of DENKA ER

DENKA ER is designed so that the use to be taken a severe durability may respond. In other words, it prepares for the grade that can cope with the various requirement of the severe durability.

DENKA ER has the grade for the use that the durability from high temperature to low temperature is taken seriously it meets, in addition more for the use that the durability to oil is taken much seriously most it meets, too.

Moreover, DENKA ER has the A series with the fast curing speed, as well which compression durability is excellent in. Though it is of course, enough the high temperature durability of DENKA ER is kept.





DENKA ER be able to find on the figure with in standing higher heat durability and selectable uses for contacted lubricant use in order to oil resistance

Approximately enduring Temperature Range and Oil-Resistance

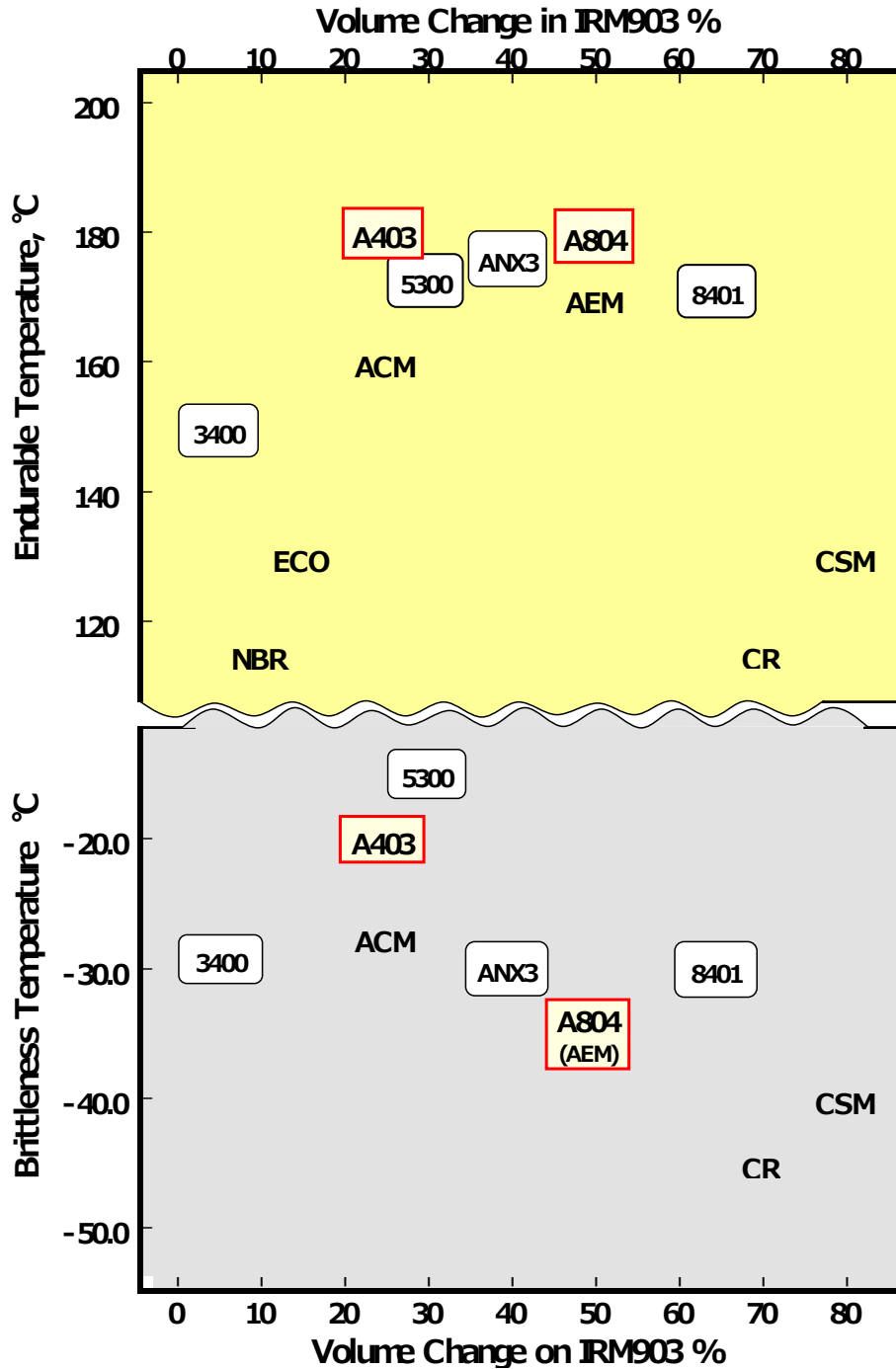
Grade	Enduring Temperature							Oil Resistance, Volume Change, %	
	-40°C	-30°C	-20°C	125°C	150°C	175°C	200°C	IRM 903 150°C, 70h	ATF 150°C, 70h
ER-3400	←←←			→				0 - 10	0
ER-5300	←←			→→→				20 - 30	5 - 15
ER-8401	←←←			→→→				60 - 70	15 - 25
ANX-3	←←←			→→→				30 - 40	5 - 15

DENKA ER

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ER A403			20 - 30	0 - 10
ER A804			45 - 55	10 - 20

IRM 903 ; New Lubricant Test Oil equivalent to ASTM No. 3 Oil
ATF ; Automatic Transmission Fluid



Heat & Oil Resistance Map

DENKA ER

Elastomer Copolymerized from Ethylene Vinyl Acetate and Acrylic Esters

Characteristic and Uses of DENKA ER

Grade	Characteristics	Uses
3400	<ul style="list-style-type: none"> The most excellent in Oil Resistance, with superior durability to Sour Gasoline, so suitable for rubber parts used incorporated with Automotive Fuel System. In a fuel resistance comparable to that of High-Nitrile Rubber, with superior durability to Sour Gasoline. 	Fuel parts Hose Oil Seal
5300	<ul style="list-style-type: none"> Heat Resistance up to 175°C with comparatively balanced performance in Oil Resistance & Low Temperature Durability. Suitable to the rubber parts used under stringent conditions especially requiring Heat & Oil Resistance, i.e., under cyclic aging exposed at high temperature within oil immersion. 	
8401	<ul style="list-style-type: none"> General Purpose type. Heat Resistance & Low Temperature Durability is the most balanced. Oil Resistance at the level comparable to Chloroprene Rubber. Suitable to the rubber parts used under severe cyclic aging condition required Heat Resistance & Low Temperature Durability. 	Oil Cooler Hose Air Duct Hose Hose Cover Gasket Packing Seal
ANX-3	<ul style="list-style-type: none"> Oil Resistance & Low Temperature Durability is most balanced. This type is also superior to Heat Resistance, and used to any other rubber parts. 	
A403	<ul style="list-style-type: none"> Excellent Compression Durability in order to have the fast curing speed, so suitable for molding rubber parts. More excellent in the Heat Resistance than DENKA ER 8401, because of a most stable cured structure. Heat Resistance with the high level performance following Silicone Rubber, reaches more than 175°C. Designed so that it can use for the molding rubber parts required with the advanced Oil Resistance. 	Oil Cooler Hose Air Duct Hose Oil Seal Gasket Packing Seal
A804	<ul style="list-style-type: none"> Excellent Compression Durability in order to have the fast curing speed and the tight cured structure, so suitable for molding rubber parts. More excellent in the Heat Resistance than DENKA ER 8401, because of a most stable cured structure. Heat Resistance with the high level performance following Silicone Rubber, reaches more than +175°C. Designed so that it can use for the molding rubber parts required with the Low Temperature Durability, kept rubber-like elasticity at approximate -40°C for a long time. 	Oil Cooler Hose Air Duct Hose Oil Seal Gasket Packing Seal

Compounding and Processing

In according to design the selection of the applicable ingredients and a formulation in DENKA ER, it is easily processed same as the other rubber material with the ordinal rubber processing machines.

Compounding Formulation

□ Recommendable Cure System

A designing of the vulcanizing ingredient is the cardinal technology that the character of the rubber product is decided as. The cure system was developed to make the most suitable for DENKA ER from many experiment data An individual our own cure system will be recommended based on this researching.

In the utility rubber parts production, it is encouraged to design it referring to our prescription example.

About the curing method of DENKA ER, the two steps method is suitable as a cure method equally with the general acrylic rubber. The press vulcanization or the steam curing is adopted as the first step method, and the air oven cure or the steam oven cure is used for the second step is suitable.

Example of curing formulation for Epoxy Grade

Ingredient		Amount & Comment
CN-25; 1-Cyanoethyl-2-Methyl Imidazole (25% in Filler)		2.0 phr
Sodium Laurylsulfate		1.0 phr
Ammonium Benzoate		0.3 phr
Evaluation of;	Safety for scorching	Good
	Stability of Stocked Compound	Very good
	Cure rate	Fair Slow
	Heat-resistance	Very good
	Compression Set	Very good

*CN-25 is developed and patented by DENKA

Example of curing formulation for Carboxyl Grade

Ingredient		Amount & Comment	
KA-4; 2,2'-bis[4-(4-Aminophenoxy)Phenyl] Propane		1.0 phr	—
Hexa-Methylene di-Amine Carbamate		—	0.6 phr
DOTG; 1,3-di-ortho-Tolyl Guanidine		1.0 phr	1.5 phr
Stearyl Amine		0.3 phr	0.3 phr
Evaluation of;	Safety for scorching	Good	Fair
	Stability of Stocked Compound	Very good	Good
	Cure rate	Fast	Excellent Fast
	Heat-resistance	Very good	Very good
	Compression Set	Very good	Very good

*KA-4 is developed and patented by DENKA

□ **Stearic Acid for Prevention of Stickiness**

DENKA ER is slightly sticky to roll and it is a necessity to add stearic acid 1.0phr or over as processing aid in the formulating.

In case of roll mixing, the surface temperature of roll is adjusted especially important at around 50°C.

If the raw rubber shall be mixed directly with an open roll, in advance the stearic acid may be blended with the raw rubber. Firstly stearic acid shall be mixed in a raw rubber, after then cut back shall be down.

The compounding can be done with a kneader or an internal mixer, in this case the stearic acid shall be added together with the reinforcing agent such as carbon black and plasticizer.

The stearic acid sufficiently dispersed in the compound releases the roll stickiness and the smoother roll mixing can be obtained.

□ **Combination of Liquid Paraffin with Stearic Acid**

In case of high stickiness formulation or smoother roll mixing required, the addition of lower viscosity liquid paraffin in amount of 1 – 3phr to do better lubricating effects of stearic acid and better processability can be obtained.

□ **Addition of Stearyl Amine for Safety Processing**

For DENKA ER A-series to need of the higher viscosity compound or the smoothest processing without a scorch trouble, the addition of stearyl amine in amount of 0.2 - 0.5phr is suggested.

However that quantity is desirable that it doesn't exceed 0.5phr, because stearyl amine has a tendency to retard the curing speed of A-Series too much.

Processing

□ **Compounding with Internal Mixing Machine**

By the formulation with Stearic Acid, Liquid Paraffin and Stearyl Amine DENKA ER can be mixed smoothly under the same condition as other synthetic rubber, but the temperature of machine rotor in the step of discharge is suggested over 60°C to make smoothly dumping from the outlet.

□ **Dump Temperature Suggestion without Curing Agent**

Even if DENKA ER has a stable chemical structure, the dump temperature of the compound mixed without curing agents is desirable under 150°C in order to keep a securable processing and in order to accomplish the safety dumping.

□ **Mixing Temperature and Processing with Curing Agent**

The compound with curing agents is generally tendency to be scorch under high temperature. For the prevention of the scorch trouble under compounding DENKA ER, it is necessary to be controlled the mixing temperature under 110°C through compounding. As the best processing, it is compounding with open roll.

When an internal type mixer cannot but be used, the two-stage compounding is suggested. At first stage DENKA ER is compounded with lubricant, carbon and plasticizer and cooling out of chamber, without curing agents, after then desirably add the curing agents.

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□ **Extrusion**

Within the ordinary temperature range at die head is suitable between from 90°C to 110°C, without big variance in extruding the rate of volume, and the die swelling, stable good extruded unvulcanizate can be obtained.

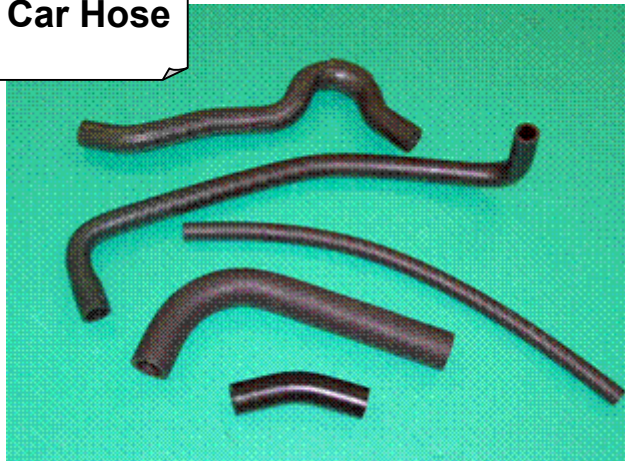
The fluidity of DENKA ER compound does not depend on temperature. As for the extruded profile form hardly change while cured in the oven. It is good characteristics of DENKA ER that can be maintained the good profile of final product.

□ **Injection Molding**

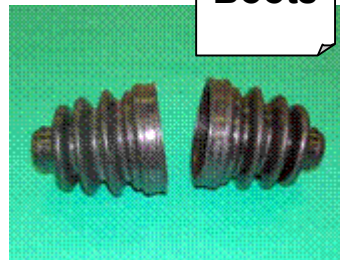
DENKA ER A-Series is improved on a cure speed and can be used for molding parts using injection machine.

Suitable curing condition of A-Series is at approximate 170°C during 5min. to 10min.. The molding temperature is increased more, and it is possible that curing time is made fast, too.

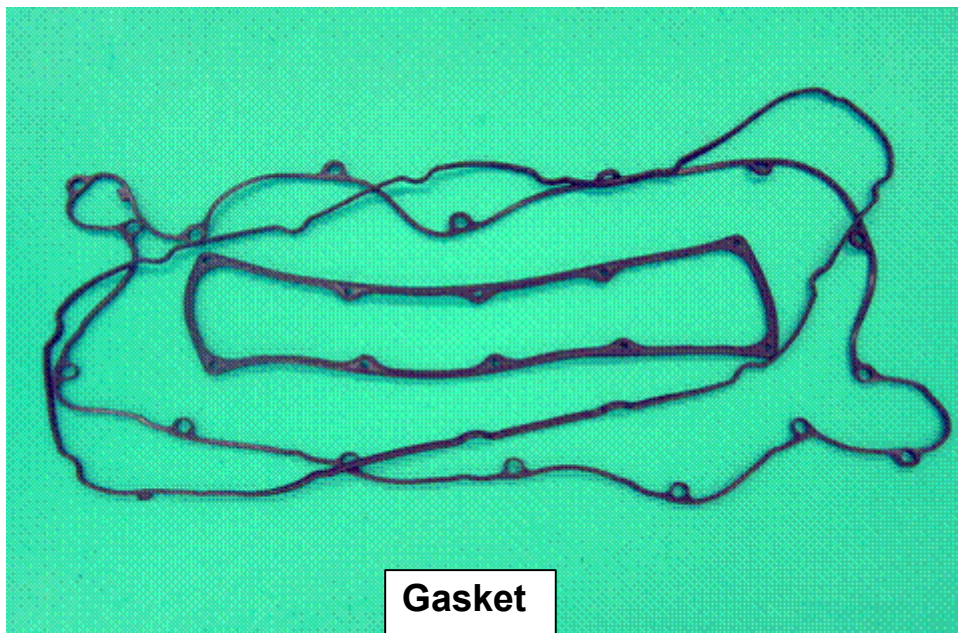
Car Hose



Boots



Gasket



DENKA ER

Elastomer Copolymerized from Ethylene Vinyl Acetate and Acrylic Esters

Summary of Properties DENKA ER [Epoxy Type]

	ER-3400	ER-5300	ER-8401	ANX-3
Unvulcanized Compound				
Mooney Viscosity ML ₁₊₄ at 100°C	50	52	50	60
Scorch 5 points rise Time Min. with ML at 125°C.	29	27	24	21
Vulcanizates; Primary Curing at 170°C, 20 min. in Press, Post Curing at 170°C, 4 hrs in Air Oven				
100% Modulus Mpa	3.7	5.4	5.5	3.7
Tensile Strength (TB) MPa	11.9	14.9	12.0	11.7
Elongation (EB) %	270	250	190	250
Hardness Shore-A	66	78	70	61
Compression Set				
at 150°C after 70hr %	46	27	28	28
Oil Resistance; immersed in at 150°C after 70hr				
Vol. Change in IRM903 %	+4	+26	+64	+37
Vol. Change ASTM#1 %	-3	+2	+18	+3
Vol. Change in Engine Oil %	+0	+11	+24	+0
Vol. Change in ATF Oil %	+0	+8	+21	+0
Low Temperature Properties				
Brittleness Point at 50% failure °C	-28	-15	-31	-28
Gehman's Stiffness Temperature				
T2 °C	-11	-5	-16	-11
T5 °C	-20	-12	-25	-20
T10 °C	-23	-15	-28	-23
T100 °C	-32	-23	-36	-32
Heat Resistance at 150°C in Air Oven after 70hr				
Retained TB %	107	102	98	103
Retained EB %	67	84	79	80
Change of Hardness Shore-A	+6	+3	+4	+5
Heat resistance at 175°C in Air Oven after 70hr				
Retained TB %	103	93	102	97
Retained EB %	63	80	79	76
Change of Hardness Shore-A	+9	+3	+4	+6

[Formulation]	phr
DENKA ER	100
Stearic Acid	1
Liquid Paraffin ¹⁾	1
Substituted diphenylamine	1
MAF Carbon	50
CN-25 ²⁾	2
Sodium Laurylsulfate	1
Ammonium Benzoate	0.3

1) Mixture of saturated hydrocarbons

2) 1-Cyanoethyl-2-methyl imidazole

DENKA ER

Elastomer Copolymerized from Ethylene Vinyl Acetate and Acrylic Esters

Summary of Properties DENKA ER [A-Series]

	ER-A403	ER-A804
Unvulcanized Compound		
Mooney Viscosity ML ₁₊₄ at 100°C	58	54
Scorch 5 points rise Time Min. with ML at 125°C.	16	11
Vulcanizates; Primary Curing at 170°C, 20 min. in Press, Post Curing at 170°C, 4 hr in Air Oven		
100% Modulus Mpa	5.6	5.6
Tensile Strength (TB) MPa	11.0	9.4
Elongation (EB) %	210	160
Hardness Shore-A	70	64
Compression Set		
at 150°C after 70hr %	9	12
Oil Resistance; immersed in at 150°C after 70hr		
Volume Change in IRM903 %	+22	+49
Volume Change ASTM#1 %	-1	+3
Volume Change in Engine Oil %	+5	+15
Volume Change in ATF Oil %	+6	+16
Low Temperature Properties		
Brittleness Point at 50% failure °C	-19	-35
Gehman's Stiffness Temperature		
T2 °C	-6	-19
T5 °C	-15	-29
T10 °C	-18	-32
T100 °C	-26	-40
Heat Resistance at 150°C in Air Oven after 70hr		
Retained TB %	95	102
Retained EB %	86	106
Change of Hardness Shore-A	+2	+5
Heat resistance at 175°C in Air Oven after 70hr		
Retained TB %	92	89
Retained EB %	100	106
Change of Hardness Shore-A	+2	+4

【Formulation】	phr
DENKA ER	100
Stearic Acid	1
Liquid Paraffin ¹⁾	1
Stearyl Amine	0.3
Substituted diphenylamine	1
MAF Carbon	50
KA-4 ²⁾	1
DOTG ³⁾	1

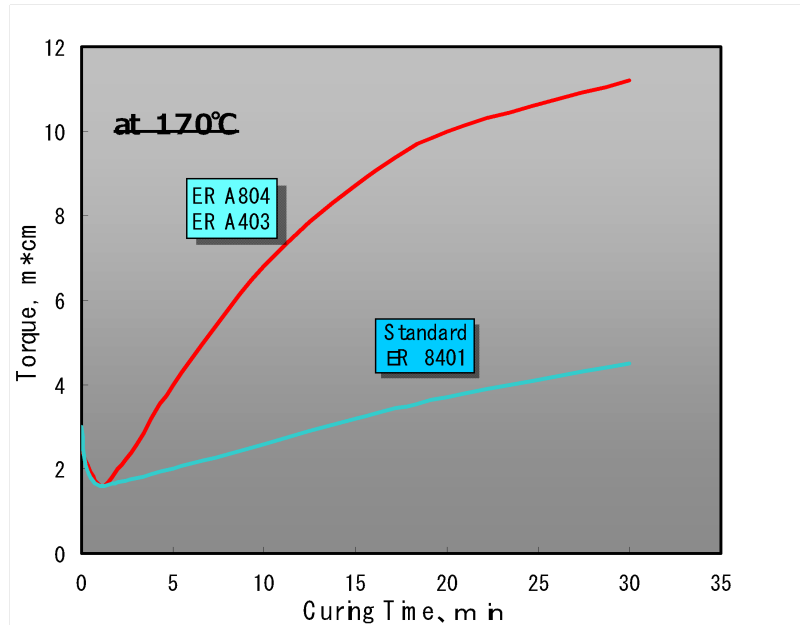
1) Mixture of saturated hydrocarbons

2) 2,2'-bis[4-(4-aminophenoxy)phenyl] propane

3) 1,3-Di-ortho-tolyl guanidine

Characteristics of DENKA ER A-Series

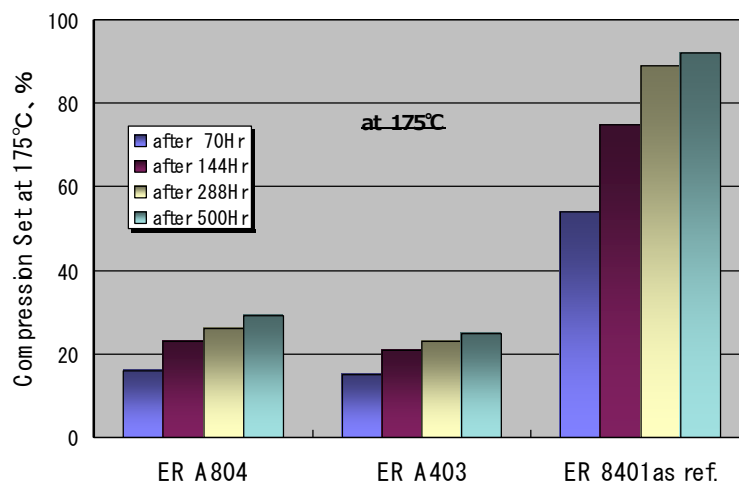
DENKA ER A-Series, A-403 and A-804 is improved on a cure speed with holding the specialty performance of the DENKA ER. The curing curve of the DENKA ER A-Series is so far by the comparison with the general-purpose grade, as shown below. DENKA ER A-series makes it possible to use not only for injection in requirement with short curing processing, but also for press molding parts.



Curing Curve for DENKA ER A-series

The most superior characteristics of DENKA ER A-series is in the point which durability against the compressed deformation under the high temperature circumstance.

DENKA ER A-series is the most suitable for the car parts such as Oil seal, Air-Duct Hose and Oil-pan gasket.



High Temperature Compression Set of Rapid Curing Type DENKA ER